WORLD ENERGY PROJECTIONS FROM THE INTERNATIONAL ENERGY OUTLOOK 1998

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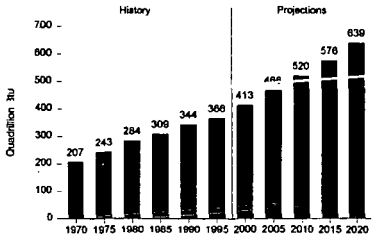
The Energy Information Administration publishes the report, *International Energy Outlook* (*IEO*), on an annual basis [1]. The report presents an assessment of world energy markets through 2020. The *Outlook* provides projections of total primary energy consumption, as well as projections of energy consumption by primary energy type (oil, natural gas, coal, nuclear, and hydroelectric and other renewable resources); and projections of net electricity consumption. By fuel projections of energy consumed for electricity generation and energy consumed at the transportation sector are also included. Carbon emissions resulting from fossil fuel use are derived from the energy consumption projections. All projections are computed in 5-year intervals through 2020.

In the 1998 edition of the *IEO*, we projected that by 2020, the world will consume three times the amount of energy it consumed in 1970 (Figure 1). Despite the economic crisis in Southeast Asia which began in the spring of 1997 and continued throughout 1998, we expect that almost half of the world's projected energy increment will occur in developing Asia. Indeed in our *International Energy Outlook 1998*, the reference case projections for Asia assumed the crisis in this part of the world would not be protracted and that the region will experience a return to the strong economic growth the region exhibited before the economic crisis. Energy demand levels should, therefore, return to the levels expected before the recession in the long run. By 2010, energy use in developing Asia (including China and India, but excluding Japan, Australia, and New Zealand) surpasses consumption in all of North America (comprised of the United States, Canada, and Japan) in our reference case. By 2020, developing Asia's consumption levels exceed that of North America by 36 percent (50 quadrillion British thermal units—Btu).

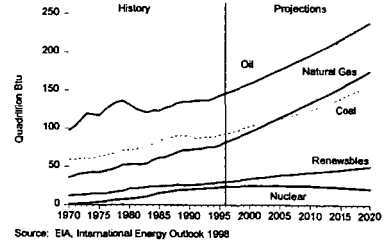
Figure 1. World Energy Consumption, 1970-2020



Source: EIA, International Energy Outlook 1998

In the 1998 reference case forecast, world energy consumption reaches 639 quadrillion Btu, growing by 2.3 percent annually between 1995 and 2020. All sources of energy, except for nuclear power, grow over the projection period. Renewable energy sources do not grow as quickly in the forecast period as they have in the past 25 years (Figure 2). By 2020, the total increment in world energy consumption from the 1995 level is projected to be about 274 quadrillion Btu, representing a 75-percent increase in total energy consumption.

Figure 2. World Energy Consumption by Fuel, 1970-2020



Source: EIA, International Energy Outlook 1998

Much of the growth in energy consumption occurs outside the industrialized world—which today consumes about 86 quadrillion Btu more than the developing world. In fact, by 2005, nonindustrialized countries (that is, the developing countries plus countries of Eastern Europe and the former Soviet Union) are expected to consume as much energy as the industrialized countries. But by the end of the forecast, energy consumption in the developing countries (developing Asia, the Middle East, Africa, and Central and South America) exceeds that of the industrialized world by 16 quadrillion Btu. Such large increases will have an enormous impact on the energy markets of the future. The projections assume substantial levels of new investment in all phases of energy production and distribution. To achieve such investment in many areas of the world, government policies must evolve, favoring private incentives for saving, trade, and development.

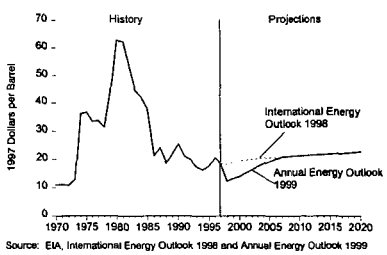
Reference Case Trends

World energy consumption is expected to reach 639 quadrillion Btu by 2020 according to our reference case projections. Much of the growth stems from increased fossil fuel use. Natural gas use is expected to have the fastest growth rate among the primary energy sources, at 3.3 percent per year between 1995 and 2020. However, the use of all fossil fuels is expected to grow faster over the next twenty-five years than it has in the past twenty-five years.

By 2020, oil consumption is expected to reach 116 million barrels per day, a 66 percent increase over the 1995 level. Oil has been the dominant energy source historically and is expected to remain so over the forecast period. However, oil demand is expected to grow more slowly than total energy consumption in the forecast, as it has for the past twenty-five years. In the industrialized countries, oil use continues to grow in the transportation sector where petroleum fuels have limited competition from other energy sources. In the rest of the world, oil demand is expected to grow in all economic sectors.

The worldwide growth in oil demand is expected to result in some increases in oil prices over the projection period. In the *IEO98* projections, prices rise from $18 per barrel (U.S. 1996 dollars) in 1995 to over $22 per barrel in 2020. The year-end 1996 price of oil was $24 a barrel. General perceptions are that near-term price risks are more heavily weighted on the downside, rather than the upside; in 1998, many analysts lowered their near-term projections by $1.00 or more per barrel for at least the next year or so, a sharp reversal of the views held early in 1997. In the *IEO98* forecast, prices were expected to recover from the lows experienced in early 1998. However, the recently released price path for our sister publication, the *Annual Energy Outlook 1999* suggest prices that do not recover until after 2005. Indeed, in the year 2000, world oil prices are more than $5 per barrel lower in this year's *Annual Energy Outlook* than they were in last year's report (Figure 3) [2].

Figure 3. Comparison of 1998 and 1999 World Oil Price Paths



Source: EIA, International Energy Outlook 1998 and Annual Energy Outlook 1999

We expect oil prices to generally stay low because non-OPEC nations will be able to continue to expand oil production in the short-term. Improvements in technology associated with oil exploration, development, and production will allow the non-OPEC production to achieve these expectations. The use of three-dimensional seismic imaging, horizontal drilling, and subsea well completion technologies has helped to extend the productive life of mature oil fields and to reduce development and production costs at new fields. While the Middle East may possess the largest portion of reserves that can be developed most economically, the reserves and production potential of other areas of the world have been substantially broadened. Nevertheless, OPEC producers are projected to gain share in the world oil production market, providing about 52 percent of the world's oil supply in 2020, compared to 39 percent in 1996.

Among all primary energy sources, natural gas is expected to grow the most rapidly, by 3.3 percent annually over the next 25 years. Natural gas resources are fairly widespread and burn more cleanly than other fossil fuels. This is particularly true in electric power generation where much of the future growth in gas demand is expected to occur. Moreover, combined-cycle gas-fired generators require shorter construction periods and are often more efficient than other fossil fuel generators or nuclear power plants. In the *IEO98* reference case projections, gas use surpasses coal by 2005, and by 2020 it exceeds coal demand by almost 18 quadrillion Btu (today, gas demand is about 13 quadrillion Btu less than coal).

There is much activity designed to expand the natural gas infrastructure worldwide. According to *Oil and Gas Journal*, in February 1997, 11,000 miles of gas pipeline were under construction and expected to be completed by the end of 1997, and over 34,000 miles of gas pipeline were planned for years beyond 1997 [3]. Natural gas demand is expected to grow most quickly in the developing world. In developing Asia, gas grows by 7 percent annually between 1995 and 2020. In Brazil alone, gas use increases by 14 percent annually in the reference case. There is robust activity in developing Central and South America's gas infrastructure needed to bring natural gas to industrial customers and electric generators. Construction began on several major pipelines in 1997, including work on the $2 billion Bolivia-to-Brazil pipeline, the first portion of which is scheduled to be completed by the end of 1998, and the entire 1,973-mile line should be finished by the end of 1999

[4].

Worldwide coal consumption in the *IEO98* grows 1.7 times above the 1995 levels, reaching 8.6 billion short tons by 2020. The strongest growth in coal use occurs in Asia in the reference case projections. Indeed, nearly 90 percent of the increment in coal use is attributed to countries of developing Asia. What's more, 95 percent of the developing Asia increase is attributed to only two countries: China and India. In these two countries, coal continues to be the major primary fuel source. Outside of China, almost all of the increase in coal use will be for electricity generation.

Coal's role in energy use worldwide has shifted substantially over the past twenty-five years, from a fuel used extensively in all end-use sectors to one that is now primarily used for primary electricity generation, and in a few key industrial sector uses such as steel, cement, and chemicals. The coal share of total energy consumption decreases only slightly over the projection period, from 25 percent in 1995 to 24 percent in 2020, mostly because of the large increases projected in developing Asia. Coal use is shrinking in Eastern Europe and the former Soviet Union and this trend is expected to continue. Slow growth is projected in the industrialized countries where decreases in coal used in Western Europe offset gains in Japan and North America. Of course, the relatively stable outlook portrayed for coal in the *IEO98* could change dramatically as a result of the reductions in carbon emissions targeted in the Kyoto Climate Change Protocol. If the proposed reductions occur, the coal industry could face a rapidly declining market for its product in the years to come.

Nuclear power declines over the forecast horizon, and the source loses share of total energy consumption, falling from 6 percent in 1995 to 3 percent by 2020. At the end of the projection period, electricity generation from nuclear energy falls below the 2,203 billion kilowatthours consumed in 1995. Use of nuclear energy peaks worldwide in 2005 at 2,368 billion kilowatthours, after which the United States and other countries with mature nuclear programs are expected to phase out the nuclear generation and retire nuclear capacity without replacing it. A substantial reduction in nuclear capacity is also expected in the former Soviet Union after 2010. Nevertheless, some countries—particularly Japan and some of the countries of developing Asia—have plans to increase their reliance on nuclear power for electricity generation.

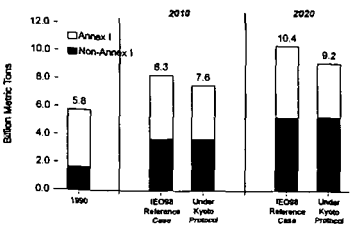
Nuclear power provided 17 percent of total electricity generation in 1996. In nine countries it provided more than 40 percent of electricity generation. Nevertheless, market competition from natural gas, public concerns about the safety of nuclear reactor operations, and problems associated with the disposal of nuclear waste products are constraining the expansion of nuclear power programs in many countries. The widespread trend towards privatization and deregulation of the electric utility sector has also undermined the viability of the nuclear option, because of the high costs associated with constructing and operating nuclear facilities. It is possible, however, that ratification of the Kyoto Protocol could change the outlook for nuclear power. Industrialized countries could conceivably extend the lives of their nuclear power plants in an effort to constrain the growth of greenhouse gas emissions.

Hydroelectricity and other renewable energy resources are expected to retain their 8-percent share of the world energy markets throughout the forecast period. Low fossil fuel prices make it difficult for renewables to compete for market share—despite the progress that has been made to reduce the per kilowatthour costs associated with generating electricity with renewables, particularly wind. In the reference case, renewables grow by 67 percent worldwide, with strongest growth projections in the developing world. There are some efforts in the industrialized world to increase the penetration of renewable energy sources to help mitigate the growth of greenhouse gases. In particular, the European Union announced a stimulus package for encouraging renewables, and plans to invest about $11 billion in wind plants in hopes of installing 10 gigawatts of wind capacity by 2010 [5].

In the *IEO98* reference case, world carbon emissions are expected to reach 8.3 billion metric tons by 2010 and 10.4 billion metric tons by 2020. According to this projection, world carbon emissions would exceed 1990 levels by 81 percent at the end of the forecast period. By 2010, emissions in the developing world are projected to be almost equal to those of the industrialized nations with 78 percent of the world's increment in emissions between 1990 and 2010 attributed to the developing countries. If the Annex I countries[1] that are parties to the Kyoto Protocol were able to achieve the proposed target reductions, the forecast for their emissions would be altered; but emissions levels

[1]The Annex I countries are defined as: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, European Economic Commission, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, the Ukraine, the United Kingdom, and the United States.

Figure 4. Carbon Emissions in 1990, 2010, and 2020 in Two Cases: Annex I vs. Non-Annex I



Source: EIA, International Energy Outlook 1998

worldwide would continue to increase (Figure 4). Meeting the requirements of the Protocol exactly would mean a reduction of more than 700 million metric tons of carbon relative to the reference case forecast for 2010.

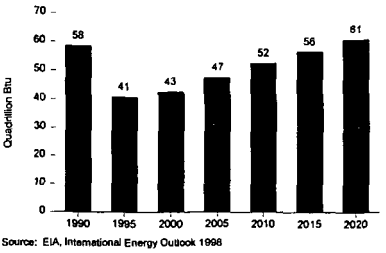
Uncertainty in the Forecast

At present, there are several areas which may be considered volatile in terms of trying to determine the future trends in energy demand. Asia is one, particularly given the recession that has remained in several key economies in the region—the largest being Japan, but also in the region's developing markets. The Asian crisis did lead to some short-term reductions in the expectations for energy use in this region in the 1998 *Outlook*. If the crisis does not soon show some signs of abating in Southeast Asia, it could have a deepening affect on the growth in energy use in developing Asia. Thailand, Indonesia, Malaysia, and South Korea currently account for just less than 20 percent of the energy use in developing Asia. The recession has already caused energy projects to be either delayed in those countries, and a quick economic recovery is key to support their completion.

Another development which could have a dramatic affect on the growth in energy consumption worldwide is the Kyoto Climate Change Protocol. No adjustments were made to the projections of energy demand based upon the effects of the Kyoto Protocol because the *IEO98* was developed based on current laws and regulations in place. While some 60 countries have signed the Protocol (including the United States, although this occurred many months after the *IEO98* was published in November 1998 [6]), only Fiji and Antigua and Barbuda have ratified the treaty. None of the participating countries had ratified the treaty at the time our report was published. The Protocol will only become legally binding when at least 55 countries, including Annex I countries accounting for at least 55 percent of these countries' 1990 carbon dioxide emissions have signed and then ratified it.

The Kyoto Protocol could substantially affect energy use in the industrialized countries. For the emissions targets specified by the Protocol to be achieved solely through a reduction in fossil fuel use, projected energy demand in 2020 would have to be scaled by between 40 and 60 quadrillion Btu—equivalent to between 20 and 30 million barrels of oil per day. Of course, the reality is that fuel-switching opportunities, emissions trading permits, and other offsets allowed under the Protocol, such as reforestation will make a more modest reduction in fossil fuel use necessary.

Figure 5. Energy Consumption in the Former Soviet Union, 1990-2020



Source: EIA, International Energy Outlook 1998

Russia and the other countries of the former Soviet Union (FSU) pose a third challenge in terms of volatility in the forecast of energy demand. In the *IEO98*, energy consumption in the FSU only overtakes the 1990 level at the end of the projection period (Figure 5). This projection was published in April 1998, before the recent devaluation of the Russian rouble. Indications are that the economy has worsened in this region enough that the forecast may well need to be scaled back even further in our next report. Moreover, the *IEO98* projected that oil production in the FSU would increase to 12.6 million barrels per day by 2020, compared to an oil consumption of 7.5 million barrels per day in that same year. However, Russian First Deputy Prime Minister Yury Maslyukov warned that unless serious actions were taken to "change the situation of the oil industry," Russia could become a net oil importer in as little as two years as the country's oil output has been in decline for the past ten years [7].

Future Considerations

As we prepare our next edition of the *International Energy Outlook*, we must address the levels of uncertainty we have about development of the world's energy markets given the events outlined above. Evaluating the long-term impact of the Southeast Asian economic recession, the length of

time it will take the former Soviet Union—especially Russia—to recover from the collapse of their centrally planned economies, and the affects of the Kyoto Protocol on industrialized countries is a difficult task. Because regional gross domestic product (GDP) growth rates are one of two major assumptions we use to derive energy consumption projections (the other is an energy elasticity measure of the change in GDP divided by the change in energy consumption), adjusting economic growth will have a substantial impact on the growth in energy use. Growth expectations for GDP in Japan, the former Soviet Union, and countries in developing Asia will be somewhat reduced compared to last year's forecast. No doubt this will result in some reduction in the energy consumption forecast for these regions. In the *Annual Energy Outlook 1999*, the world oil demand projections showed a slight downward adjustment of 1.4 million barrels per day by 2020 from last year's *IEO*.

As of November 1998, none of the Annex I countries had ratified the Kyoto Protocol treaty so it is unlikely that this year's *IEO* reference case projections would be altered to incorporate the treaty. However, we expect to continue to address the potential effects the Protocol might have on various energy markets worldwide.

References

1. Projections that appear in this paper are taken from the Energy Information Administration, *International Energy Outlook 1998*, DOE/EIA-0484(98) (Washington, DC, April 1998).

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